JWSN , 2015, 2, 1- 0004

Journal of Wireless Sensor Networks

ISSN: 2001-6417

www.wsn-journal.com

Article

Comparative study of several MAC protocols proposed in WSN

Ridha Azizi

High Institute of Technological Studies of Sousse (ISET); Erriadh district - Sousse - 4032 Tunisia. azizi_ridha@yahoo.fr

Received: 16 April 2015/ Accepted: 26 July 2015 / Published: 27 July 2015

Abstract: The lifetime of a sensor network is closely linked to the nodal life. The latter depends mainly on the power consumption of the node. We presented in this work some approaches to energy conservation in wireless sensor networks. The first area of energy conservation techniques aimed at reducing the duty-cycle nodes. This results in the reduction in the duration of radio activity to avoid excessive energy consumption due to communication. In this context, several methods have emerged either as MAC protocols low Duty-cycle or as independent higher-level protocols based on authorizations Sleep / Wakeup. The objective of this work is to do a thorough study on energy consumption in wireless sensor networks. The study points addressed are at the level of media access protocol or MAC protocol.

Keywords : Wireless sensor networks, fault tolerance, MAC protocol suitable for WSN, Sensor-MAC, TimeOut-MAC, Wise-MAC, Lightweight MAC, TRAMA, MAC protocol of IEEE 802.15.4

1. Introduction

A WSN consists of a number of interconnected sensors that are able to survey the environment in which they are located and pass the information to certain nodes (Sink) deployed in a position to relay the large-scale information as illustrated in the following diagram. WSN form a new generation networks with specific properties that do not fit in conventional architectures. They have a very broad scope, covering several areas of scientific, logistical, military or health.

2. MAC protocols for WSN

2.1. The characteristics of a suitable MAC protocol for WSN

In order to design the MAC protocol best suited to the specific characteristics of WSN, we must consider the following properties: [7]

- **The "Throughput"**: this is the amount of successfully transmitted data between a transmitter and a receiver in a definite time. It is a fairly important feature in the case of applications that require a good "throughput".
- **Equity** : It reflects the ability of the sensor nodes to share the channel fairly. In the case of WSN, this property is not taken into consideration since all nodes work together, regardless of the amount of information transmitted by the various nodes to perform a common task.

  This property remains very important in conventional wireless networks that each node wants to have the same chance as the other nodes for transmitting or receiving data.
- **The energy optimization**: this property is the most important of all in the case of WSN. Indeed, the fact that it is difficult to change or recharge the batteries of the nodes, is a real handicap that limits their lifespan. As the MAC layer controls the activities of the radio layer, which in turn consumes the most energy, then we can deduce that the MAC layer can manage this consumption trying to prevent the loss
- **The waiting** : This is the time between the transmission time of a message and the time of receipt successfully. The importance of this feature is dependent on the type of application.

  While conventional MAC protocols are designed so that they maximize the "throughput", minimize latency and ensures equal opportunities for transmission (fairness). The MAC protocol design for WSN mainly focuses on minimizing energy consumption. [10]
- **Adapting to change**: WSN networks are dynamic in their size, density or their topology; So in this case, an efficient MAC protocol must carefully manage these changes without a network malfunction.

2.2 Energy consumption at the MAC layer in WSN

We will try in what follows to analyze the reasons energy loss at the MAC layer in WSN :

- **Collisions**: in the case of a collision between two or more packets, the latter will be rejected and therefore transmitted by their issuers. The webcast will increase the energy consumption of sensor nodes issuers.
- **The phenomenon of "idle-listening" or passive listening**: It appears when the node is still listening to the medium to receive data possible. It is very costly in energy especially in the case of applications that do not require virtually a large data exchange. The cost of the energy consumption in radio communications type depends on both the transmit hardware / receipt and distance. Indeed, whichever is greater, (Case of WLAN, WWAN) the consumption cost due to listening and reception is negligible compared to that due to the transmission.

  However, in the WSN where the distance is small, the energy consumption cost due to passive listening is almost the same order of magnitude as that due to the receipt and issue.
- **The phenomenon of "Overhearing" or "On-listening**": this means that the node receives packets that are normally intended for other nodes. This can be a major cause of energy loss in the case of a high density area with traffic enough voluminous.
- **The phenomenon of "overemitting" or "On-emission"** is caused by the transmission of a message to a node that is not yet ready to receive data.

  The synthesis of this part leads us to conclude that for WSN which are generally characterized by their high density and not much traffic, the phenomenon of "idle listening" or passive listening is the main cause of the loss of energy in the sensor nodes.

3. Comparative study of some proposed MAC protocols in WSN

3.1. The comparison criteria

To achieve this comparative study, we relied on the following four criteria:

- The allocation of the radio channel.
- Notification
- Energy Management
- Quality of service.

3.1.1. The allocation of the radio channel

In radio frequency communications, if there is more than a node that wants to transmit data on the same channel at the same time, while communication problems such as collisions or distortion can arise. To avoid such problems, some of the bandwidth is allocated to each node. This allowance can be either static or dynamic:

- **Static Allocation** : This allocation technique divides the bandwidth into N parts. Each party is allocated to a node. Multiplexing techniques used to divide the bandwidth have been described in the first part of this chapter and are: TDMA, FDMA and CDMA. In general, the MAC protocol in WSN, employing a static allocation of the channel, using the TDMA technique. This technique requires synchronization between nodes to allow each node to identify its time slots. Synchronization in the case of WSN is distributed such that each node or group of nodes generates its own sequence of states that will be adjusted periodically. Centralized synchronization is not applicable in WSN because this kind of network suffers from high latency and packet loss fairly common. So in the event of a delay or loss of sync signal, the network will be disrupted.

- **Dynamic allocation** : In this technique allocation, there is no bandwidth allocated in a predefined manner for each node. Any node wishing to access the channel must win restraint. With this type of allocation, there is a high probability of collision.

3.1.2. Notification

To successful communication between transmitter and receiver, it must be listening channel when transmission starts. Thus, it will be notified of the existence of a transmission on the channel. This notification can be classified into two types:

- **By reservation**: This type of notification is used by protocols based on a static channel allocation, where the nodes have predetermined slots for transmission or reception. Lightweight-MAC protocol is an example that uses this type of notification.
- **By listening to the channel**: In protocols using dynamic allocation the channel, there is no predetermined slots to transmit or receive data. A node can always be tuned channel waiting to receive a transmission intended for it. Although this listening method could increase the chances of receiving the message, this method is too costly in energy. To avoid such losses, nodes periodically change their "sleeping" state and "active". Listening to the channel can be synchronous or asynchronous:Synchronous: the sequence of states "active / sleep" is determined by an exchange of synchronization messages. Each node knows when will these neighboring nodes are active. Thus the sender node waits until the receiver enters the active state to transmit its message. Sensor-MAC and MAC-TimeOut are protocols which employ synchronous listening to the channel.
- **Asynchronous**: The nodes do not know when is what their neighbors are active. They then shall periodically tuned channel to check if there is a transmission that will take place. This method is known under the name of "Preamble Sampling". Wise-MAC uses this type of listening channel.

3.1.3. Power management

This criterion will be treated with the advantages and disadvantages in terms of energy management, each MAC protocol described above.

3.1.4. QoS

Unlike traditional networks where the basic components of quality of service are the bandwidth, fairness and latency. These components are, for the majority of MAC protocols proposed for WSN (except for the MAC protocol of IEEE 802.15.4), sacrificed at the expense of optimizing the energy consumption of sensor nodes. This does not mean that the quality of service need not included in this type of network, except that it is essentially dependent on the type of application running at the WSN. Indeed, Sensor-MAC designers, Time-Out or MAC-MAC Wise had the first goal, the energy consumption reduction to maximize the network lifetime which was fine with the applications they use (military ...). However, and for the case of the MAC protocol of IEEE 802.15.4 (standard used for purposes of applications for the general public), bandwidth and latency for example are service quality parameters strongly taken into account.

3.2. The comparative tables

The following table shows the classification of MAC protocols proposed for WSN, according to four criteria has been described previously (The allocation of the radio channel, notification, energy management, quality of service).

Protocol	**Sensor-MAC**	**TimeOut-MAC**	**Wise-MAC**	**Lightweight MAC**	**TRAMA**	**MAC protocol of IEEE 802.15.4**
Allocation of the radio channel	Dynamic based on CSMA	Dynamic based on CSMA	Dynamic based on CSMA	Static centralized synchronization, based on TDMA	Static centralized synchronization, based on TDMA	Dynamic based on CSMA
Notification	Listen synchronous channel	Listen synchronous channel	Listen synchronous channel	per booking	per booking	Listen asynchronous channel
Quality of service	Absent	Absent	Absent	Absent	Absent	Present

Table 1: Comparative Stady of Some MAC Protocols In WSN

4. Experimental Study

4.1 Choice of protocols

Among the protocols included in the mac layer, we chose to evaluate three (SMAC, IEEE802.15.4 and TDMA). In our comparative study, the emulation protocols can be made based on two architectures: Sink architecture and architecture point to point. In addition, protocols are selected according to their appearance in time (TDMA SMAC and are considered the oldest while the protocol concerned IEEE802.15.4est most recent).

4.2 Sink Architecture

The operation of the SMAC protocol IEEE802.15.4 and TDMA is determined by the current state of the network (nodes / Sink) and on the basis of their energy consumption. In this context, we have implemented these protocols on our simulator to study their energy consumption over time. This study will be presented in three curves representing three different scenarios for each protocol, ranging from one scenario to another, the number of source nodes.

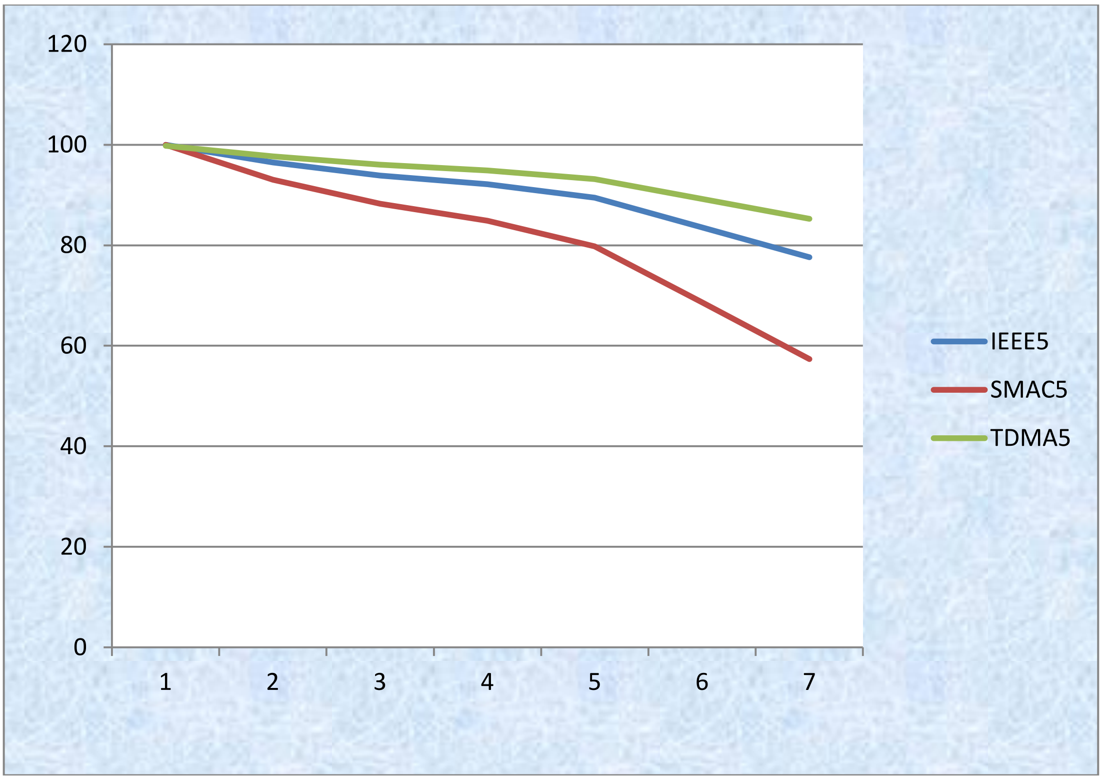

Figure1 : Energy consumption in the model " node to Sink "

In the curve of SMAC (stained red), energy at T = 0s is 100Watt decreases more and more until it reach 57.383 Watt at T = 435. It may be concluded while the TDMA protocol is the best since it uses less energy qu'IEEE802.15.4 and SMAC is least maintaining

4.3 point to point architecture

The operation of the SMAC protocol IEEE802.15.4 and TDMA is determined by the current state of the network (point to point) and on the basis of their energy consumption. In this context, we have implemented these protocols on our simulator to study their energy consumption over time in the architecture point to point. This study will be presented in three curves representing three different scenarios for each protocol, ranging from one scenario to another, depending on the number of source nodes.

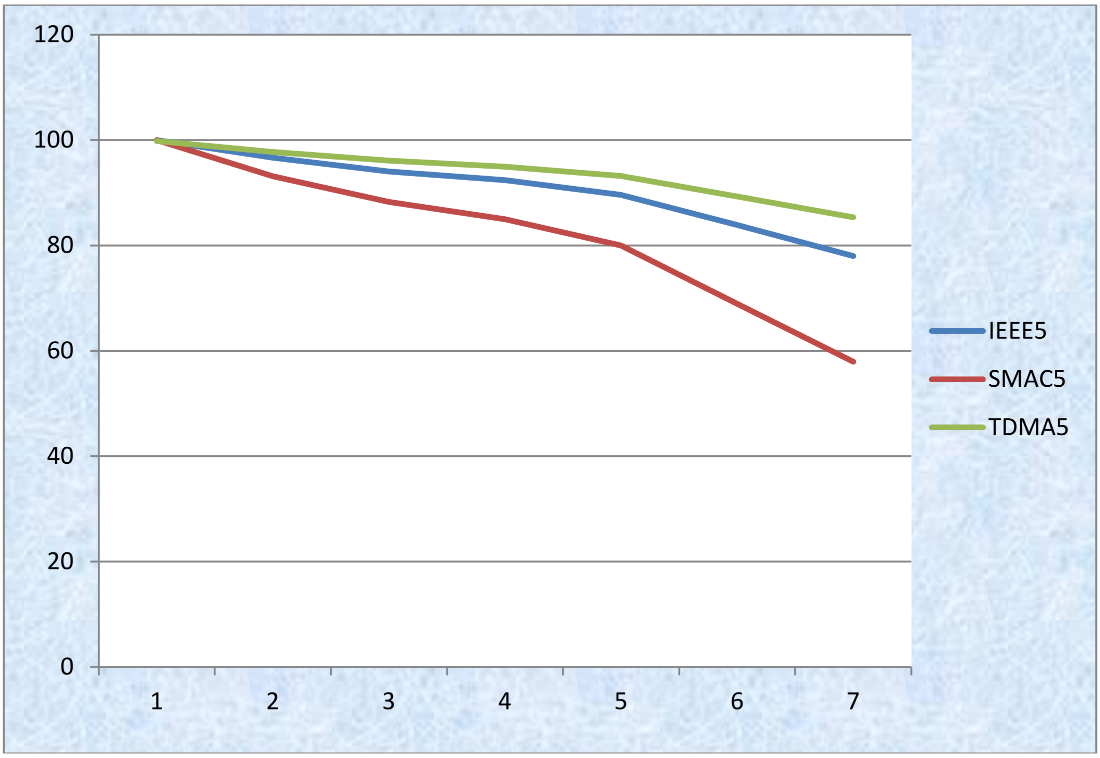

Figure 2 : Energy consumption in the model "point to point "

The initial energy was determined in all simulations to 100 Wat. In the curve of the TDMA (stained green), energy at t = 0 is 100 Watt decreases more and more until it reach T = 435s 85,34Watt. In the curve of IEEE802.15.4 (stained blue), energy at T = 0 is 100 Watt decreases more and more until it reach T = 435s 77.977 Watt. In the curve of SMAC (stained red), energy at T = 0s is 100Watt decreases more and more until it reach 57.904 Watt at T = 435. Then one can conclude that the TDMA protocol is the best since it uses less energy qu'IEEE802.15.4 and SMAC is least keeping.

5. Conclusion

Several MAC protocols for wireless sensor networks have been proposed, and many states of the art and introductions to MAC protocols are available in the literature. We mainly focus on energy management issues rather than on access to the channel methods. Most of them are implementing a diet with a low duty-cycle to manage energy consumption. We have identified the most common MAC protocols by classifying them into three categories: TDMA based protocols, protocols using restraint and hybrid protocols. In this paper, we conducted a comparative study of some protocols of the MAC layer. We found that the protocols of the existing MAC layer are dedicated either to guarantee the reliability or to control congestion in a unidirectional sense. It is necessary therefore to show that the MAC layer must perform good transfer without energy dissipation to prolong the life of the sensor the maximum possible.

6. References

[1] Pujolle G., (2005) "Networks Editions 2005" Eyrolles.

[2] J. Zheng, Myung L., (2004) "Will make ubiquitous IEEE 802.15.4 networking is reality? "The city College of CUNY, IEEE Communications Magazine,.

[3] I. Akyildiz, W. Su, Y. Sankarsubramaniam, Cayirci E., , (2002) "A Survey on Sensor Networks," Georgia Institute of Technology, IEEE Communications Magazine.

[4] Holger K., A. Willig, ,(2003) "A short survey of wireless sensor networks," Technical university Berlin, Telecommunication Networks Group.

[5] Lee, G., Kong, J., Lee, M., and Byeon, O. A cluster-based energy-efficient routing protocol without location information for sensor networks. Journal of Information Processing Systems, 1(1), 49-54.

[6] D. Culler, D. Estrin, M. Srivastava, (2004) "Overview of sensor networks," University of California, Berkeley, IEEE Computer Society.

[7] E. Fleury, G. Chelius, Cute T., (2003)"minimization of energy in sensor networks," CITI Laboratory / INSA Lyon.

[8] Demirkol I., C. Ersoy, F. Alagöz, (2003)"MAC Protocols for Wireless Sensor Networks: a Survey",

[9] B. Lwakabamba, (2004)"Performance analysis experiments for the wireless sensor networks integrated Into the C6 virtual reality environment," Iowa State University,.

[10] J. Heidemann, W. Ye, D. Estrin, (2002)"An Energy Efficient-MAC Protocol for Wireless Sensor Networks," IEEE Infocom.

[11] Van Dam, Langendoen K., (2003) "An Adaptive EnergyEfficient MAC Protocol for Wireless Sensor Networks", Faculty of Information Technology and Systems, Delft University of Technology, Netherlands,.

[12] W. Ye, J. Heidmann, (2003) "Medium Access Control in Wireless Sensor Networks", USC / ISI Technical Report ISI-TR-580,.

[13] Decotignie JD, El-Hoiydi A., C. Enz, E. Le Roux, (2003) "WiseMAC, an Ultra Low WiseNET Protocol for the Wireless Sensor Network", ACM SenSys'03, Los Angeles, USA,.

[14] Akkaya, K., and Younis, M. A survey on routing protocols for wireless sensor networks. Ad Hoc Networks, 2005,3(3), 325-349.

[15] Diwan, R., and Thakur, S. Role of data link layer in OSI. International Research Journal, 1(7), ISSN-0975-3486,2009, RNI: RAJBIL 30097.
[16] Azahari, A., Alsaqour, R., Uddin, M., and Al-Hubaishi, M. Review of error detection of data link layer in computer network. Journal of Engineering and Applied Sciences,2014,20 9(1).
[17] Azizi. R (2015) "Comparative Study of Transport Protocols in WSN" in International Journal of Computer Applications (0975 - 8887) Volume 113 - Issue 6,
[18] Shukla, K.V.Research on energy efficient routing protocol LEACH for wireless sensor networks. International Journal of Engineering Research and Technology, (2(3)) ESRSA Publications.